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A SPHENOPSID FROM THE LOWER DEVONIAN OF WYOMING

BY

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Sphondylophyton *Schultes & Dorf gen. nov.*

Herba laxe caespitosa ut videtur, ex axibus simplicibus aliquid flexuosis constans. Axes appendices complanatas, probabiliter rigidas, basi dichotomas, foliosas incurvatas verticillatas ferentes. Verticilli parte terminali (?) congesti, inferne laxiusculi. Fructus ignoti.

Plant apparently loosely caespitose; composed of unbranched, somewhat flexuous axes bearing flat, probably stiff, basally dichotomous leaf-like appendages which are disposed in whorls rather widely spaced except near the tips (?) where the whorls are crowded. Fructifications unknown.

Sphondylophyton hyenioides *Schultes & Dorf sp. nov.*

Herba laxe caespitosa ut videtur. Axes simplices, flexuosi, plus minusve 3 cm. longi (probabiliter imperfecti), 1–2 mm. lati, verticillos ferentes. Verticilli e duabus ad quattuor appendicibus foliosis constant. Appendices complanatae foliosae, basi ramosae, incurvatae, probabiliter rigidae; segmenta truncato-linearia, aequalia, 5–8 mm. longa, plus minusve 1–2 mm. lata. Verticilli regulariter dispositi, inferne inter se 4–6 mm. distantes, partibus apicalibus (?) congesti. Fructus ignoti.

Plant of apparently loosely caespitose habit with unbranched, flexuous axes averaging 3 cm. in length (probably incomplete) and 1–2 mm. in width, bearing whorls of from two to four leaf-like appendages. Leaf-like appendages flat, stiff (?), basally dichotomous, with the two segments equal; segments truncate-linear, 5–8 mm. long and 1–2 mm. in width. Whorls regularly disposed, 4–6 mm. apart, except on the terminal (?) portion of the axes where the whorls are more closely packed and the leaf-like appendages are more or less incurled. Fructifications unknown.

Paleobotanical Collections, Princeton University, No. 24101; Beartooth Butte formation, Lower Devonian, Beartooth Butte, Wyoming.

Geological considerations

The type specimen of this genus and species was collected by Dorf during the summer of 1934 from the Lower Devonian Beartooth Butte formation (6) at Beartooth Butte, Wyoming. The fieldwork in this area was conducted under the auspices of the William Berryman Scott Fund of Princeton University.

The Beartooth Butte formation has been shown (6) to be a local channel-fill deposited in quiet, shallow, non-marine water under estuarine conditions. The lens-shaped deposit is separated from the underlying Bighorn dolomite of Upper Ordovician age by a marked disconformity, and is overlain disconformably by the Middle Devonian Jefferson limestone.

Plant remains were found in the channel-fill in direct association with a large Lower Devonian fauna of ostracoderms, arthrodires, elasmobranchs, eurypterids, and a questionable dipnoan (2,3,13). Five distinct types of plant remains have previously been described from this locality (4,5). The present form is the sixth. The floral evidence substantiates the Lower Devonian age reference based on the primitive fishes.

The plant fossils, as well as the best preserved fish remains, occur in a massive, mouse-gray, argillaceous limestone, weathering to grayish and pinkish buff. These beds are well exposed in the eastern scarp face of Beartooth Butte between thirty and ninety feet above the base of the deposit.

Botanical considerations

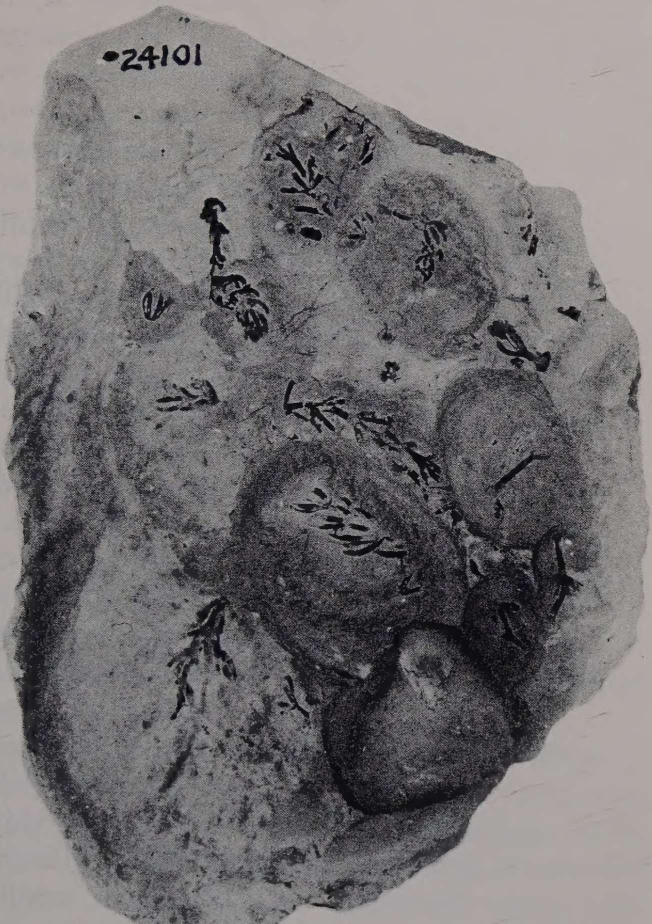
Sphondylophyton hyenioides apparently was a loosely tufted plant growing in a frequently flooded habitat. It is probable that all of the disconnected axes preserved on specimen No. 24101 (Fig. I) belong to the same plant. Their appearance suggests that they might have arisen from a single basal portion and were more or less flattened out centrifugally in several directions before or during preservation. They may have rotted off and fallen into the wet mud at the exact place of growth. Since no fragments of the axes of *Sphondylophyton hyenioides* have been found on any other specimens collected from the fossiliferous horizon, it argues that the fragments associated so closely together on specimen No. 24101 did not float in from some other location, but were probably attached to the same base and were preserved essentially in place.

The axes appear to be unbranched, and, although the length of the shoots may have been somewhat longer than in the fossil, it is probably true that sufficient lengths are preserved to warrant the statement that the plant did not branch above the base. It is certain from the specimen that branching was rare if it did occur.

The axes appear also to have been capable of standing more or less erect and of supporting the relatively large

EXPLANATION OF THE ILLUSTRATION

FIGURE I. SPHONDYLOPHYTON HYENIOIDES *Schultes & Dorf gen. et sp. nov.* Heliotype reproduction of a photograph of the type specimen. Three fifths natural size. Paleobotanical Collections, Princeton University, No. 24101; Beartooth Butte formation, Beartooth Butte, Wyoming, U. S. A. Lower Devonian.


24101

whorls of foliar appendages. It has not been possible to find traces of internal structure by means of peel and maceration techniques. Material for anatomical study is extremely limited since only one specimen of this plant is known. It has been impossible, even under relatively high magnifications, to find a definite ridge which might have been a vascular strand. The aspect of the entire plant, however, suggests, by comparison with other known vascular plant-fossils of similar nature, that it must have been vascular in structure.

An important aspect of *Sphondylophyton hyenioides* is the presence of leaf-like appendages or foliar organs in whorls. The verticillation is more regular than in *Hyenia sphenophylloides* Nathorst (7,12) or than in *Hyenia elegans* Kräusel & Weyland (9,10) of the Middle Devonian of Norway, Germany, and other parts of Europe. The whorls in *Sphondylophyton* are regularly spaced (Fig. II), on the lower fragments of axes averaging four to six millimeters apart; on the several shorter pieces, the whorls are placed about one to three millimeters apart. The axes bearing these crowded whorls are further distinguished by having the foliar organs curled into a bud-like mass. Consequently it is probably safe to assume that these portions are terminal.

The form of the foliar organs is also of extreme interest. They were apparently flat, somewhat coriaceous, and possibly more or less stiff. Each appendage of the whorl is basally dichotomous into two equal or subequal truncate-linear segments. The ''terminal'' axes, however, possess foliar organs of a different shape. The segments of the appendages are slightly incurved, pointed and curled together into bud-like masses. Whether or not any significance attaches to this difference is still a question.

That the lower portion of the axes was probably naked (lacking whorls of appendages) is suggested by the presence of a "leaf-less" axis measuring 1.5 centimeters in length (Fig. II). This may be the basal portion of one of the closely adjacent "leafy" axes.

Unfortunately, in the material at present available, no fertile parts are recognizable. Consequently, the solution of the extremely important problem of the form and placement of the sporangia of *Sphondylophyton hyenioides* must await the discovery of further material. It is not impossible that the several portions which appear to be terminal (with closely set whorls) may actually be sporangiophoric in nature.

The close resemblance of the axes of *Sphondylophyton hyenioides* to certain algae must be considered. In megascopic aspect, this plant does not seem to be remote from some of the whorled algae. This may be significant in placing *Sphondylophyton* very near the ancestral algal type in the origin of the sphenopsids. The whorled condition is not uncommon among the algae, especially among the grass-green algae, the *Chlorophyceae.* The microscopic *Algites Cranii* Kidston & Lang (8) (*Characeae* ?) of the Lower Devonian of Rhynie, Scotland, possesses a verticillately branched axis. Among the freshwater algae of the present, the *Characeae* (species of *Chara* and *Nitella*) are whorled. Arber (1) points out that *Crouania* and *Lomentaria* resemble the sphenopsid habit, but are, of course, marine forms.

It is suggested, however, that *Sphondylophyton hyenioides* represents a land plant of the early sphenopsid complex and not an alga. The reasons for this opinion may be stated as follows: 1, *Sphondylophyton* grew in association with a typically terrestrial flora; 2, the habitat was non-marine, occasionally flooded by fresh water, and no living non-marine verticillate alga nor any known whorled fossil algal form is so large as *Sphondylophyton*;

3, the plant remains are more heavily carbonized than appears to be possible for a member of the family *Characeae* and probably for any alga.

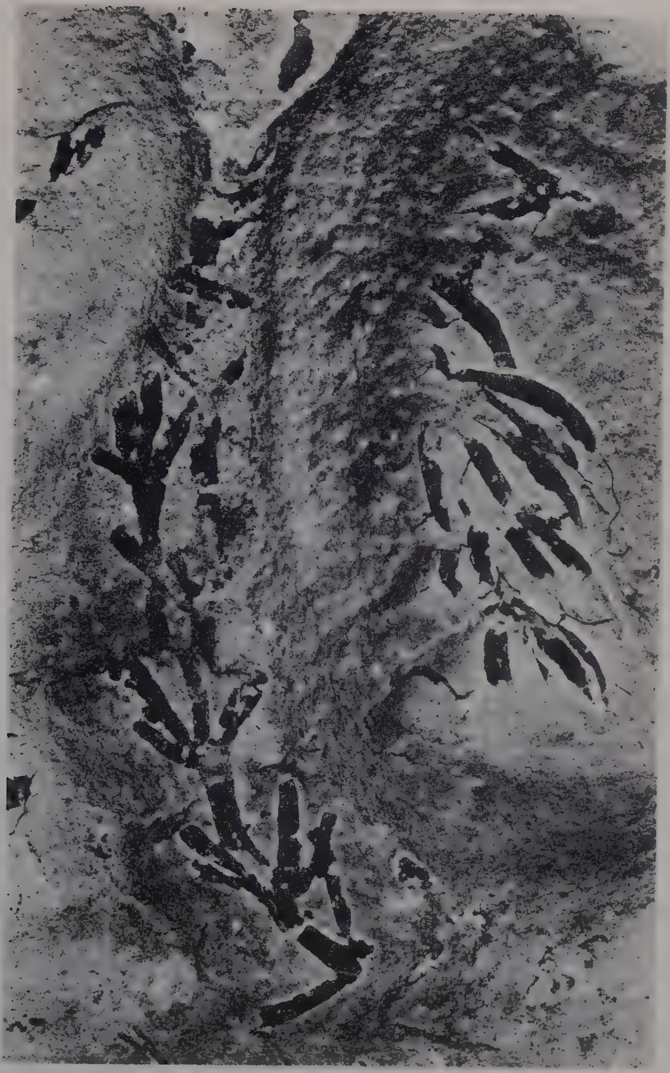
Until more sphenopsids are discovered in Lower Devonian or Upper Silurian rocks, the forms most closely related to *Sphondylophyton* can be inferred only from megascopic characteristics. It may be said, however, that *Sphondylophyton hyenioides* is best interpreted as an early member of the *Sphenopsida.*

As the specific name of the plant implies, *Sphondylophyton* bears a striking resemblance to *Hyenia sphenophylloides* Nathorst (7,12) and to *Hyenia elegans* Kräusel & Weyland (9,10) of the Middle Devonian, hitherto the earliest known undoubted sphenopsids. The general tufted habit of the plant and the verticillation of the foliar organs correspond rather closely with that of the two species of *Hyenia.* There are, however, marked differences: *Sphondylophyton* has no longitudinal striations on the axes, has foliar organs once (basally) instead of twice dichotomous as in *Hyenia,* and has, in general, a more thalloid habit than *Hyenia. Sphondylophyton* is much more alga-like in appearance than *Hyenia.* For these reasons, and because of the lack of fertile material, the Wyoming sphenopsid deserves generic rank.

Climaciophyton trifoliatum Steinmann & Elberskirch (11,14) is a sphenopsid of the Lower Devonian of Germany. Until the discovery of *Sphondylophyton, Climaciophyton* was the only known Lower Devonian plant of possible articulate affinity. It is curious, however, that beyond the verticillation, *Climaciophyton* bears no close resemblance to *Sphondylophyton,* and it is probable that the relationship between the two forms is distant. The leaf-like appendages of *Climaciophyton* are more or less obtusely triangular with a number of nerves. Moreover, *Sphondylophyton* is a much larger plant than *Climacio-*

EXPLANATION OF THE ILLUSTRATION

FIGURE II. SPHONDYLOPHYTON HYENIOIDES *Schultes & Dorf gen. et sp. nov.* Heliotype reproduction of a photograph of a portion of the type specimen, enlarged three times. The color of the rock matrix is a dull pinkish-buff. The photographs for Figures I and II were taken through a red filter with the specimen submerged in xylol. Paleobotanical Collections, Princeton University, No. 24101; Beartooth Butte formation, Beartooth Butte, Wyoming, U.S.A. Lower Devonian.



phyton. The presence of these two articulate elements in the Lower Devonian floras projects the history of the *Sphenopsida* much farther back than was formerly the case, and, since they occur on two different continents, the pre-Devonian history of the *Sphenopsida* may have been as long as that of the parallel groups of the Devonian—the *Psilopsida* and the *Lycopsida.*

Sphondylophyton hyenioides occurs as an element of a typical Lower Devonian "*Psilophyton*-flora". The Beartooth Butte flora of Wyoming (4, 5) is the only known representative of this simple and primitive association of plants in the western part of North America. Included in the flora are such forms as *Hostimella sp.*, *Psilophyton wyomingense* Dorf, *Bucheria ovata* Dorf, and *Bröggeria strobiliformis* Dorf. The discovery of *Sphondylophyton hyenioides* together with these Devonian psilopsids and other simple plants is the first evidence of definitely sphenopsidal elements in the "*Psilophyton*-floras" of North America, and the second in the Lower Devonian of the world.

Summary

Sphondylophyton hyenioides Schultes & Dorf of the Lower Devonian of Wyoming is a plant of tufted habit, the axes bearing whorls of relatively large, dichotomous, thalloid foliar appendages. It is the first actual evidence of the sphenopsids in the "*Psilophyton*-floras" of the Lower Devonian of North America and the second in the floras of that age in the entire world. In its habit, the plant is much nearer an ancestral algal form than is any previously known sphenopsid.

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A NEW TRANSFER METHOD FOR STUDYING FOSSIL PLANTS

BY

William C. Darrah

The microscopic study of fossil plants has made many great advances since Henry Witham published his histological investigation of several fossils from Great Britain in 1833. His study comprised notes on twelve species prepared by the thin section method, by which translucent sections could be ground from slices sawn from petrified specimens. This method has been in general use for more than a century.

More recently translucent sections have been prepared by the peel method. A specimen is etched with a suitable acid in order to dissolve the inorganic matrix and expose the carbonized portions of the preserved plant structures. Following this step, a solution of nitrocellulose in butyl acetate is poured over the etched surface. After the nitrocellulose has dried it can be peeled off, pulling with it a nearly perfect replica of the preserved structure.

The thin section can be subjected to magnifications from 100 to 250 times, but the thickness of the glass slide, the thin section of the fossil, and the cover glass collectively prevent the use of higher magnifications—at least with transmitted light. A ground section is almost always more than one cell thick.

The nitrocellulose peel, in contrast, may be so prepared that the thickness of fossil is from one to three micra, frequently much less than one cell in thickness. However, the thickness of the nitrocellulose is relatively great. Even so, magnifications greater than 500 times are usually permitted, and occasionally excellent photographs can be made at magnifications of 1200 times.

One of the great problems attendant upon the study of fossil plants with structure preserved is the difficulty involved in using high magnifications. The use of oil immersion objectives has hitherto been impractical.

Several months ago, my colleague, Doctor A. Orville Dahl suggested the possibility of preparing a peel and subsequently freeing the occluded plant structures by redissolving the nitrocellulose. With this purpose in mind, I tried a number of procedures on various types of fructifications with encouraging results.

A peel containing spores or pollen grains is carefully cropped with scissors and the selected portion is set aside for the transfer of the spores or pollen. Then a glass slide is thoroughly cleaned and moistened with a droplet of albumen (egg-white). The slide is air dried in a dust-free place for twenty minutes and then the peel is impressed in the albumen. The glass slide with the peel adhering to it is placed in a container of butyl acetate and is permitted to stand until all of the nitrocellulose has been dissolved. This is usually accomplished in three or four hours. When this transfer of the spore or pollen grain has taken place, that is, the body is now imbedded in the albumen instead of the nitrocellulose, the slide is removed from the solvent and is gently dipped into butyl alcohol. The albumen can then be completely dehydrated with absolute ethyl alcohol, and the fossil quickly covered with balsam and a cover glass. Such a permanent mount can be studied in the same manner as a similar preparation of parts of extant plants.

With this new tool, paleobotanists may be able to find gametophytes among those extinct ferns which are supposed to have been endosporal in development, and to investigate the male gametophytes of the early seed plants.

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